Rec.Models.Rockets FAQ
(Frequently Asked Questions)

Part 8: Boost Glider and Rocket Gliders

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8.1 R/C Rocket Gliders

The D-G powered R/C rocket gliders now available are presenting some new problems to ModRoc'ers, who are more used to making balsa wings, fins, etc., then built-up wings. Here is a set of tips submitted by Iskandar Taib, a long time model plane enthusiast, and others. There is an excellent FAQ in the rec.models.rc news group. It includes very good information on how to get started into R/C flying, tips on where to buy equipment, etc.

8.1.1. Have there been any construction reviews of R/C rocket gliders?

Aerotech Phoenix: August, 1992, "Model Builder Magazine"
Estes Astroblaster: September, 1992, "Model Builder Magazine"

Both articles are written from the perspective of experienced R/C aircraft modelers. They both contain good construction and flying tips.

8.1.2. I'm building the 'XXX' R/C Rocket Glider and it uses foam core wings. Are there any things I should know about working with foam?

The first thing to know is that certain paints and glues dissolve foam. Both the stuff made out of white beads (referred to as "bead-board") and the blue (Dow Styrofoam (tm)) or pink (DuPont Foamular) extruded foam will behave in the same way. Once sheeted a foam wing can sometimes be finished in a paint that ordinarily dissolves foam if one is careful about not putting too much on at a time. Here is a list of what will dissolve styrofoam and what won't:

Will dissolve foam:

- Nitrate and butyrate dope
- Ambroid
- "Model Airplane Cement" (you know what I mean)
- Polyester resin (sold as "fiberglass resin" at K-Mart)
- Thick and thin cyanoacrylates (excepting UFO)
- Paints from spray cans
- Dope and paint thinners
- Gasoline
- Dope thinner, acetone
- Solvent-based contact cements

Won't dissolve foam:

- Polyurethane paints and varnishes (inc. Rustoleum)
- White or aliphatic glues (Elmer's, Titebond)
- Epoxies
- Ethanol or methanol (sometimes used to thin epoxies)
- UFO superglues
- Water-based contact cements (eg. Southern Sorghum)

Follow the instructions provided and you won't go wrong. Most structural building is done with white glue and epoxy is used for sheeting the wing and/or putting down fiberglass, graphite or kevlar cloth.

8.1.3. Any tips for sheeting the wings on my Aerotech Phoenix?

The Phoenix kit requires that you sheet the wing with balsa using epoxy as the glue. Aerotech also recommends that you vacuum-bag the wing for the lightest wings possible. Vacuum bagging is a fairly new technique that I will describe later.

The process involves preparing the wing skins, mixing the epoxy (needless to say, the 24 hour laminating variety, spreading it on the skins with a squeegee, scraping most of it off, applying the skins to the core, then assembling everything together in the core beds (the pieces left over after the core is cut), and putting lots of weight on top of the whole thing. Oh yeah.. the wing has to be kept straight so you'd have to do this on a very flat surface. The more pressure you can put on this, the better glue joint you'll have, and the less glue you'll have to use, which makes for a lighter wing.

VACUUM BAGGING

This is where the vacuum bagging comes in. The core bed/sheeting/core assembly is put into a large bag which is sealed on all sides. Then the

air is pumped out of the bag. This is supposedly the equivalent of piling hundreds of pounds of weights on the core. In fact they tell you to limit the vacuum to so many inches Hg otherwise the cores will crush.

Vacuum bagging is also useful if you are going to lay up fiberglass on top of the balsa wing skins. Fiberglass cloth is now available in very light weights and people often use it in lieu of a covering film or fabric.

The way it used to be done was that the cloth was laid down and a thinned (with alcohol) epoxy brushed into it. Then excess epoxy was removed using rolls of toilet paper (discarding layers as they became saturated).

With vacuum bagging one lays down a sheet of drafting mylar on top of the wet glass cloth, then puts the assembly in core beds. The assembly is then vacuum-bagged. After curing the mylar sheets are removed and you end up with a glass-like finish that is extremely light since all excess epoxy has been squeezed out. This also obviates the need for lots of the filling and sanding usually necessary before painting.

8.1.4. How about help with my Estes Astroblaster wings?

The Astro Blaster kit uses contact cement for sheeting the wings. The cement is of the water based variety. It is applied to both skin and core and is allowed to dry. After this has occurred, the skins and core can then be brought together. This is a little trickier, since you don't get a second chance. Once the core touches the skin you can't separate them without breaking something. The skins are just 1/32" thick so one has to be gentle with them.

8.1.5. How do you repair damaged foam wings?

Repairing foam is fairly easy. One simply hacks out the damaged piece, glues in a block of foam and carves and sands to shape. Carving is best done with a brand new utility knife (the kind that has break-off points) and sanding can be done with a sanding block. Sheeting is replaced in the same manner - cut out the damaged piece and glue on a replacement. A little glass cloth or carbon fiber matte over the break helps too.

8.1.6. Some more uses of foam in rocketry...

Foam is interesting stuff to play with. You can cut wing cores using a hot wire and 1/16" ply or formica templates. Parts for rockets can be made by simple carving and sanding.

Even more interesting is making lightweight wings and other parts using foam, silkspan and thinned white glue. Someone called Ron St. Jean built lots of competition free flight models in this manner. The silkspan is applied wet over the foam, and thinned white glue is brushed on. When the silkspan dries it shrinks, and the result is an incredibly strong and stiff structures. One could conceivably use this method for nose cones or complex scale models. In England, foam and brown wrapping paper is used for complex ducted fan models (someone actually flies a seven foot long scale Concorde constructed like this).

If one uses heavier paper (eg. grocery sacks) perhaps one can dissolve the foam once the white glue is set (use acetone or dope thinner for this). For rockets imagine something shaped like a V2 made like this. Once the foam was dissolved you'd end up with a light weight craft paper tube of the proper shape, boat tail and all.

8.1.7. I need to cut the piano wire control rods. Bolt cutters don't work well, as the metal is too hard. Any ideas?

From: ntaib@silver.ucs.indiana.edu (Iskandar Taib)
What you want to do is get your hands on a reinforced cutting wheel like the House of Balsa Tuf-Grind. The Dremel ones tend to shatter and throw pieces at high speed. If you use them harden them with thin superglue.

8.2 Free Flight Boost and Rocket Gliders

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8.2.1 What is the difference between a Boost/Glider and a Rocket/Glider?

In a Boost/Glider (referred to as a BG in the rest of the FAQ), only a portion of the rocket as launched is required to come down gliding. In a Rocket/Glider (RG), the entire model remains in one piece, and the whole model glides down. BGs can be higher performance because they do not have to carry the dead weight of the motor while gliding down. But sometimes that extra mass is helpful in trimming the model, and RGs have the advantage of not having to chase multiple pieces. Typically, this distinction is only important in NAR competition, where these two classes are distinguished. An RG is a legal entry in BG events, but a BG is not a legal entry in RG events.

The other thing to distinguish is a philosophical distinction between a BOOST/glider and a boost/GLIDER. The question is which half of the flight the emphasis is on. A BOOST/glider is a rocket that happens to have glide recovery. In reality, it probably doesn't glide that well. The Space Shuttle and Tomcat kits are good examples of this type of glider. A boost/GLIDER on the other hand is a high performance glider that is carried aloft by a rocket motor. These are the type of models typically seen in competition, and the topic of most of this FAQ.

Also note that regardless of the emphasis, all of these gliders are launched within 30 degrees of vertical, like all other model rockets. Horizontal launch and shallow climbing supported by wing lift doesn't work for these models, and is prohibited by the safety code.

8.2.2 What are some types of gliders?

Early BGs were rear engine designs. The first was built by John Schutz and Vern Estes in 1961. They usually looked like delta-winged jets or X rockets. The old Estes Space Plane is an example of this style.

In 1963 Larry Renger invented the front engine BG with the forerunner of the Sky Slash. It was basically a hand launched glider with a motor pod hung on the front. The old Estes Falcon followed this style. A few years later, Larry invented the detachable "pop" pod. Almost all gliders today are front engine design, and pop pods are the most common of the BGs flown today. The old Centuri Swift and Estes Dragonfly (refer to the Rocky Mountain Canary for the original version that performs much better) were Pop Pod designs, as is the MPC/Quest Flat Cat.

Parasite gliders are smaller gliders attached to the outside of larger conventional model rockets. They can be as simple as a small foam glider hooked to an extra launch lug on the side of a standard model rocket. Many of the popular mass market kits fall into this category, including the Estes Manta, ARV Condor, Space Shuttle and the old Orbital Transport, the Centuri Pterodactyl and the Quest Aurora.

Flex-wing (FW) gliders were inspired by the Rogallo wing that was originally intended as the recovery device for the Gemini program. They are basically 3 sticks with a lightweight plastic covering. They fold for boost inside a long skinny rocket, and eject like a parachute. NAR competition rules prohibit "flexies" as they are called in BG and RG events, and create a separate category for them.

Gliders are further broken down into categories describing how they look or work. Some of them are fixed pod, pop pod, swing wing, slide wing, box wing, t-rail, slide pod, no moving parts, canard, auto-elevator, variable camber, flop wing, scissor wing, flying wing, swept wing, flapped wing, delta wing, Rogallo wing, etc.

8.2.3 What are all these funny names I see referenced?

Until the 1979 Pink Book revision, different power classes were designated by names. For gliders, the names were of flying creatures. Here is a decoder table:

1/8A	[none]
1/4A	Gnat
1/2A	Hornet
A	Sparrow
B	Swift
C	Hawk
D	[no official name. The "Pink Book" used to lump D and E into one category. Sometimes called Deagle or Falcon]
E	Eagle
F	Condor
G	[no official name. This class did not exist back when names were used, but was occasionally referenced as Dragon]

8.2.4 I'm just starting. What kits or plans are available?

Several model rocket manufacturers make glider kits. Very few make really good gliders. Among the non-spectacular performers are the Estes Space Shuttle and Tomcat, and assorted parasite and foam gliders.

The Quest Flat Cat is an improvement on an old design that can fly reasonably well. Edmonds offers several excellent glider kits, also sold by Apogee and BMS. QCR has several glider kits, including a good booklet on flex-wing gliders. The Estes Trans-Wing and MRC Thermal Hawk are reasonable fliers.

NCR glider kits are gone, but plans may resurface in the future. Eclipse has a few glider kits as well. Holverson had some unique gliders, but they've been replaced with RTF foam that just isn't what the old kits were. Apogee had glider kits, but I don't know what their status is today.

My favorite BG plan for the beginner is the Flanigan Flyer, designed by Chris Flanigan of the MIT Rocket Society. Plans for it can be found in the MIT Competition Notebook available from NARTS. It is suitable for A-C 18 mm motors.

Try Mark Bundick's Parksley Eagle for 13 mm 1/2A & A motors, available from NARTS in the "NIRA Glider Plans from 'The Leading Edge'" reprint. There are several other glider related NIRA Reprints also available from NARTS. Guppy's Fish & Chips (1/2A) and High Performance Sparrow (A) BG (both in the MIT CN) were some of my favorites, but are very touchy to trim (more about

that later), thus not recommended for beginners.

For C/D BG I've been flying a Gold Rush HLG using either a C6-3 or a C6-3/A3-4T cluster. While I haven't tried it, the Apogee D3 should work fine with this model. Many of the outdoor HLG designs are suitable for this class glider. Also check out Trip Barber's D-Light in the Nov/Dec 1997 Sport Rocketry.

For higher power events, the old Centuri Pterodactyl parasite glider is one of the few models that can hold up to composite motors.

For a first RG, I recommend the Seattle Special, by George Riebesehl. Plans for this model are also in the "NIRA Glider Plans from 'The Leading Edge'" reprint. It flies on A-C 18 mm motors. For 13 mm motors, try Tom Beach's Status-4 in the Winter 1995 issue of Sport Rocketry. A good D RG is George Gassaway's Stiletto-D from the May 1985 issue of American Spacemodelling [http://members.aol.com/RBGliders/Stiletto_D.htm].

For a FW, I recommend the QCR kit and manual. This proved good enough for NAR V.P. Trip Barber, a fellow FW hater, to take a first place with at NARAM-37, building the glider right on the field. Also refer to George Gassaways articles in American Spacemodelling, December 1980 and September 1986.

Many more plans are available from NAR, NARTS, NARTREK, NFFS, and AMA publications. See the references at the end of the FAQ.

Many competition plans are now on the NAR competition web site at http://www.nar.org/competition/plans/competitionPlans.html. Dozens of classic glider kits and plans are available on the JimZ web site at http://www.dars.org/JimZ

8.2.5 Why do most gliders have the rudder under the fuselage?

This is probably more for historical rather than technical reasons. Since the motor is on top, a conventionally placed rudder would be in the exhaust. In reality, some glider tails are far enough from the exhaust that it often doesn't matter. The real question should be "Why do airplanes have the rudder on top?" :-) Aerodynamically, most would be better off with bottom rudders, but that would get in the way of minor things like wheels and the ground.

8.2.6 These things are very different from what I've built before. Are there any tips for building them?

Lots of them. The most important things to consider are to build light, strong, and warp-free. Weight is the enemy of a glider. A weak glider will break easily. A warped glider is very difficult to make glide properly. All three of these problems are hard to fix later.

Weight and strength are tradeoffs. Reducing one usually reduces the other. Weight must be controlled when building. This starts by selecting the right wood. Many kits from big manufacturers have really awful wood. If it's bad, replace it with better wood from a hobby shop or mail order supplier. More on this later. Proper shaping not only improves the airfoil, but removes excess weight. I prefer to build light, and then reinforce the glider with composite materials, thus minimizing weight and maximizing strength.

In order to keep surfaces straight and free of undesirable warps, I recommend the use of a building board. A scrap of kitchen counter, larger than the finished model is perfect for this purpose. A scrap hollow core door can also make a large workbench and building board. 2x4 ceiling tiles work well, and you can pin plans to them easily, but they can be damaged easily. The building board should have at least one straight perpendicular edge. All planing, sanding, cutting, and gluing is done on this work surface.

The flying surfaces of most gliders need to be airfoiled to work best. Unlike other rocket parts, a glider wing needs a non-symmetric airfoil. The standard fin airfoil shape, split in half, is a good place to begin. To rapidly shape a wing airfoil, use a device called a razor plane. Much like its big brother used for carpentry, this tool shaves off wood quickly. The difference is that it uses a razor blade or equivalent to do so. Many different types are available. My personal favorite is the David Combi. An inexpensive nylon one is available from Master Airscrew. The cheap cast metal planes that use double edge razor blades are usually of poor quality. These and many other handy tools can be found in model airplane catalogs. The SIG catalog in particular is an excellent source of many materials needed to build and fly gliders, including these two razor planes.

Once roughly shaped, a sanding block is needed to get everything smooth. A 6" piece of 1x2 is perfect to wrap 1/6 of a sheet of sandpaper around (or 1/3 of a sheet around a 12" block). Use thumb tacks to hold the sheet in place. The extruded aluminum sanding blocks are particularly nice for airfoiling glider wings. Sanding across the grain removes wood fast, sanding with the grain gives a nice final finish. Start with 100 grit, and work down to 400. The stab and rudder are similarly airfoiled, usually symmetrically. Note that Delta wing and canard (stab in front, wing in rear, like some of the Rutan aircraft designs) gliders often need different airfoils. Consult the instructions or plans for your model.

In order to be stable in glide, your glider will need dihedral. This is the upward tilting or curving of the wings. Some designs use multiple joints, trihedral or polyhedral. To do this, cut the wing in half (or thirds, quarters, etc. as per the plan). A razor saw is the best tool to do this, but a modeling knife and a straight edge will do. Tilt each tip up the required amount on your building board. Use a handy scrap or a piece of 1x2 to prop the wing pieces up. Now bevel the root edges using a sanding block

and the edge of the building board so that they are once again perpendicular to your work surface.

The two edges can now be glued together. Standard wood glues can be used for this, either carpenters, CA, epoxy, or Amberoid or Duco. I particularly like Amberoid or Duco cement for gliders because it can be dissolved to remove parts that end up misaligned. For extra strength poke several pinholes in the edges to be joined before gluing.

The wing, stab, and rudder are now glued to the fuselage of the glider. Take care to align the parts accurately. Typically a design will call for a tilt in the wing or stab, in order to make the glider gently turn in flight. This prevents very long chases to retrieve your glider. Also designs will frequently include a few degrees of negative incidence or decalage in the stab. By putting the stab at a slight pitch angle to the wing, it aids in the transition of the glider from boost to glide, and prevents the "death dive" where the glider flys straight down. This angle can be set by tapering the fuselage at the attachment point, or by gluing a small block at the appropriate end of the fuselage to support the stab.

8.2.7 [How] Should I paint my glider?

Most competition models are not painted in a normal sense. Many gliders are left totally unpainted. Some modelers will color the model with magic marker or a thin layer of model airplane dope for visibility. Others will apply a coat or two of clear dope to prevent warping. I personally prefer Japanese Tissue and dope (discussed later), as it adds both strength and color to the model, at a very minimal weight penalty.

Conventional finishing techniques of filler, primer, paint, and decals should be left to models where glide performance is not a concern.

8.2.8 Can I convert a hand launched glider (HLG) to rocket power?

Yes. The cheap balsa "snap together" toy gliders (i.e. North Pacific) are *NOT* strong enough for flight conversion; their wings are too thin and will shread. Plans for Jetex models are usually too flimsy for model rocket power [I've estimated that a Jetex motor is about an A 0.2-P in the NAR system].

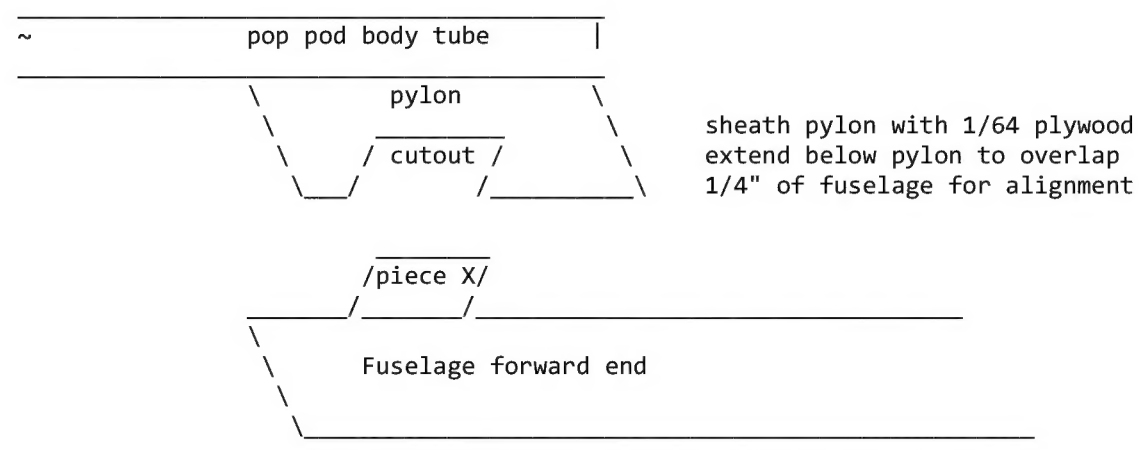
However many HLG kits and plans are convertible. Also look at the Catapult gliders, essentially HLGs flown with a fixed size rubber band instead of arm strength. A wealth of HLG plans are available from the Academy of Model Aeronautics (AMA), National Free Flight Society (NFFS), Zaic yearbooks, and some of the other RC modeling magazines. I highly recommend the NFFS newsletter, journals, plans, and publications as sources of free flight glider information.

Usually, all you need to do is to add a pop pod (or a fixed pod if you want to keep things simple) to the HLG, and perhaps invert the rudder. The references at the end of this part of the FAQ list several good HLG plans.

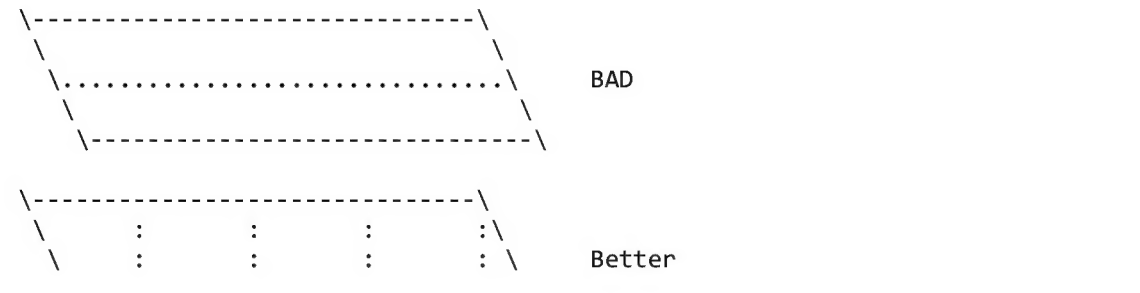
8.2.8.1 How do I attach a pop pod to a glider?

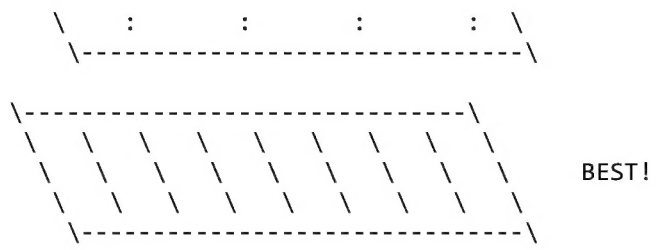
Some sort of positive hook is needed, yet it must be designed to separate easily at ejection. Once common method is the "Piece X" or xerclod hook, where a rhombus hook is cut from the fuselage and attached to the pop pod. Use a razor saw for most of this cutting. The fuselage is then sheathed with thin balsa or plywood around the notch. This creates a weak spot in the fuselage where it can break, especially during trimming.

I prefer to cut the Piece X from the pop pod and glue it to the fuselage:



A common mistake is to have the pylon grain, be it pop pod, fixed pod, or other design run parallel to the fuselage. It results from cutting the pylon from the same stick as the fuselage. DON'T! This is bad for the same reason you don't have the fin grain run this way, it can easily break off. For maximum strength, both the pylon and the piece X should have their grain running parallel to their leading edge. That requires discarding the piece X cut from the pylon, and cutting out a new one, regardless of whether you cut the X from the pylon or the fuselage. An acceptable compromise is to have the grain run perpendicular to the fuselage, so the piece X is usable.





Other attachment methods use a dowel or pin, external hooks of thin plywood glued to the outside of the pod/fuselage, nested square brass tubing (see

8.2.9 I'd like to design my own glider. How do I know if it will work? How do I compute the CP for a glider?

First, build a few kits or plans and get some experience with gliders. Designing a successful glider is a lot more complicated than designing a successful rocket. Once you've mastered building, trimming, and flying some existing designs you are ready to try your own.

Glider stability is similar to a rocket stability, but a bit more complicated. The equivalent to a rocket Center of Pressure (CP) is called the Neutral Point (NP) of a glider. There is an article on how to calculate this in the 1980 MIT Journal available from NARTS. I've used a program I wrote (FORTRAN-IV for RT-11 and VMS) in the early 80s to calculate the NP. Versions of this program for DOS and LINUX are finally available on the net at

ftp://eagle.he.net/pub/cssinc/Private/NP.zip.

Just as a rocket CG needs to be ahead of the CP, a glider CG must be ahead of its NP for it to be stable. 10-20% of the wing chord (the distance from the leading edge to trailing edge of the wing) is a good margin for free flight models. RC models can get by with much smaller margins.

Here is a sample output of my neutral point program. The program itself is based on a paper presented by Guppy at MITCON-11, and a later summary in the MIT Journal.

The Flat Cat data is from the Quest model, emailed to me by Andy Eng. I make no claim to its accuracy. I.E. if it's wrong, it's Andy's fault. Andy specified all the surfaces as being 1/8" thick! I "corrected" this, making the stab and rudder 1/16", which sounds more reasonable to me. Besides, the thickness is just used to calculate the frontal area; it doesn't affect the NP calculation. I was surprised to see the NP at 85% of wing chord. I'd really like someone to try trimming this model with the CG at 70% back and let me know how it glides.

```
Description: Flat Cat                                                 |               |
Wing:   Span=  15.500     Root=  2.7500     Tip =  1.3000     PSpn=  14.671
        Swep=  1.4500     Thck= 0.12500     Dihd=  2.5000     Angl=  18.819     Frnt= 1.9375    >
        MAC =  2.0250     Area=  29.710     AR  =  7.2451     Xac = 0.42413     L   =0.81490E-01>
Stab:   Span=  6.5000     Root=  2.0000     Tip =  1.0000     PSpn=  6.5000     %Wng= 0.32818
        Swep=  1.0000     Thck= 0.62000E-01 Dihd=  0.0000     Angl=  0.0000     Frnt=0.40300    >
        MAC =  1.5000     Area=  9.7500     AR  =  4.3333     Xac = 0.41667     L   =0.65391E-01>
Fin:    Span=  1.5000     Root=  2.0000     Tip =  1.0000     PSpn=  1.5000     %Wng= 0.75733E-01
        Swep=  1.0000     Thck= 0.62000E-01 Dihd=  0.0000     Angl=  0.0000     Frnt=0.93000E-01>
        MAC =  1.5000     Area=  2.2500     AR  =  1.0000     Xac = 0.41667     L   =0.30000E-01>
Front:  Dia = 0.75000     Hgth= 0.50000     Thck= 0.25000
        BstA=  3.0003     GldA=  2.4960     Bdia=  1.9545     Gdia=  1.7827     Semi= 1.1474    >
Tail:   Momt=  6.0000     QCM =  8.4170     TVC =  1.3641     FVC = 0.43448E-01 Wash=0.70190    >
The Neutral Point is located at  85.38% (   2.348     units ) from wing L.E.    NPg = 1.1540
Stability factor 0.20 Put CG at  70.65% (   1.943     units ) from wing L.E.    NPb =0.99614
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There are several good articles on Boost Glider Stability in old Model Rocketry Magazine and Model Rocketeers. Reprints of many of these are available from NARTS and/or NARTREK.

When scratch building, selecting good balsa wood is important. SIG has a great reference on balsa grain and density in their catalog. Look for pieces of wood with straight grain, and no knots or swirls. For wings and stabs choose as uniform a piece as possible so you don't have density variations in the surface. Also avoid splits and cracks. See also question #13.

There's an article in the MARS Pathfinder newsletter with a V-tail BG design and calculations at: http://www.marsclub.org/path/MP15-3.pdf

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8.2.10 What motor should I use to fly my glider?

Typically, you want a low average thrust and a short delay for a glider. For example, a B class model would probably do better with a B4-2 than a B4-4 or a B6-2. The Apogee 10 mm BP motors are ideal for small gliders. Be careful of motors with large ignition spikes, like the A10-3T or C5-3, unless you want to re-kit your model. Core burning motors, including most composite motors are not usually suitable for gliders. The Apogee end burning composites: C4, D3, E6, and F10, are ideal glider motors.

The new Quest Micro Maxx motors have sparked the development of some very small lightweight gliders. See:

http://members.aol.com/GCGassaway/GENERAL/Czechmicroglider.GIF
http://www.wizvax.net/jvincent/qmm.html
http://hometown.aol.com/peterlynnc/rockets.html

JimZ even suggests using Micro Maxx motors on some WhiteWings models.

8.2.11 This thing looks weird sitting on the pad. How do I launch a glider?

Since the motor is usually near the front of the glider, there isn't much left of a 3' launch rod once you put a glider on the pad. Frequently the glider will fall off the pop pod while sitting on the pad. The other big problem is that once the motor ignites, the clips fall, and can catch in the wings or stab of the glider.

The solution to all of these problems is to launch gliders from a "Power Tower". This is nothing more than a 3' dowel with a launch rod on the top. Sharpen one end of the dowel, and pound it into the ground. You can drill a hole for the rod, or just tape it in place. I like to bevel the end of the dowel at a 45 degree angle. A scrap ceramic tile with a hole drilled near an edge makes a good blast deflector. Make sure that the exhaust is directed AWAY from the glider, and not back into the wing! The pop pod now sits on the deflector, and the glider hangs below the rod, against the dowel.

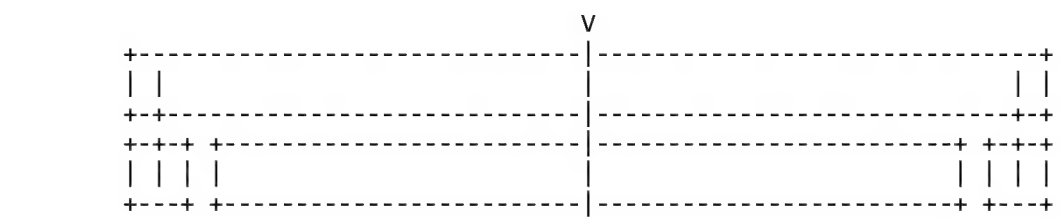
To prevent the clips from catching the tail, you can either tape the clip lead to the dowel, or better yet, use a second launch rod about a foot away as a gantry, so the clips fall away from the glider. A couple more rods are handy if it is a bit windy to prevent the glider from blowing off the pop pod, or twisting on the pad. Space them out near the wing tips.

I've gone one step farther, and made a 1/2 size version of a Chad Pad. The base of the Chad Pad has extra holes in each "leg" for extra launch rods to keep the wind from blowing the glider around, and uses another rod as the gantry for the ignition wires:

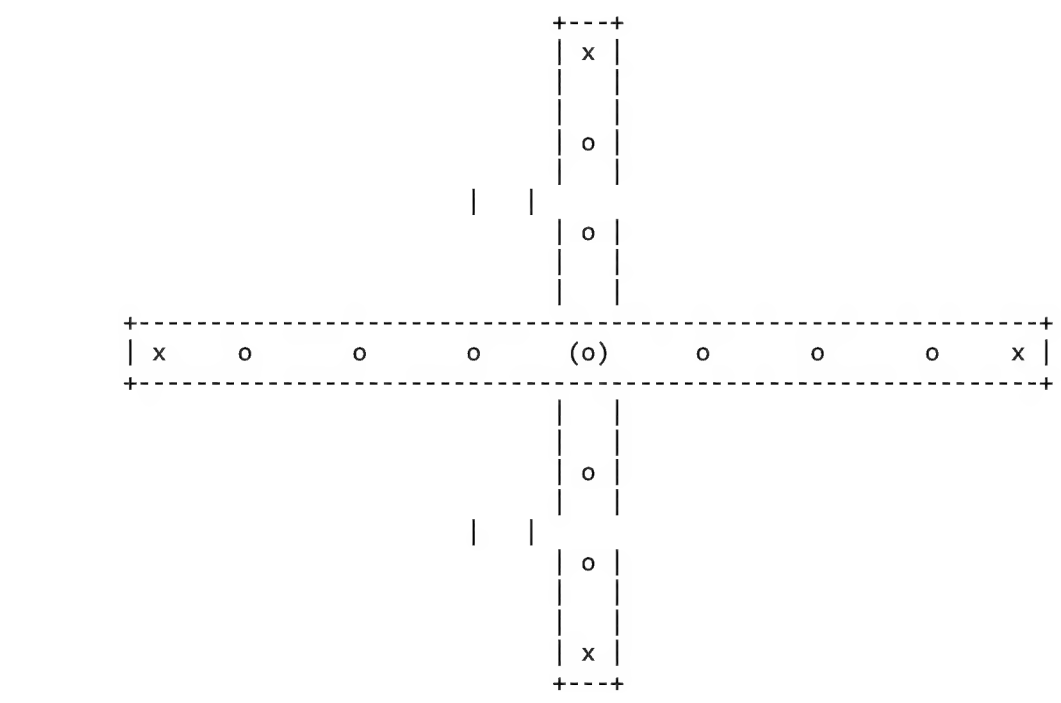
KGB Mini "Chad Pad" and tower parts list:

1	4' 1x2 (I used poplar instead of pine)
1	1/4"x2 carriage bolt
1	1/4" wing nut ("V" in drawing)
2	1/4" washers
1	1/4" lock washer
4	1.25" screws or nails
4	16p nails (double headed nails are most convenient)
1	ceramic tile, or stainless scrap
1	3/4" or 1" x 36" straight dowel
1	1/4" T-nut

Chad pad crummy ASCII art: (folded for storage)



and opened



The original chad pad was built from 8' of 2x4, I built a smaller one of 4' of 1x2 for gliders. Take your 1x2 and cut it almost in half, with one piece about 1/2" shorter than the other. From the short piece cut a square off each end. Nail or screw the two squares to the ends of the now significantly longer piece. Drill a 1/4" hole through the center of the two long pieces, and put a carriage bolt up through the bottom, with a washer in the middle, and another washer, lock nut, and wing nut on top. With the wing nut loose, the whole thing now closes up as above, or opens into an "X". Drill holes in each of the 4 ends for the 16p nails to add stability.

For the glider version, Bunny and I added a 3' dowel with a threaded insert epoxied into the bottom. Cut the top at a 45 degree angle so the blast deflector sends the exhaust away from the model (I use a scrap ceramic tile or piece of stainless steel here) and add hole(s) for the desired rod size(s). Remove the wing nut, and screw the dowel into the carriage bolt, lifting the model up 3' off the ground. Perfect for gliders. Add some holes along both base 1x2 for extra launch rods to keep the glider wings from being blown around in the wind, and to use as a gantry for the wires.

Finish the whole thing as you choose to protect the wood. Bright colors or Aerotech style hazard colors might be a good choice to prevent people from tripping on it. Rust-o-leum BBQ black is a good choice to withstand repeated rocket exhaust.

8.2.12 My glider looped and crashed into the ground. What is wrong?

First check for a warp or misalignment in the wing or stab. These are the most common cause of boost problems, and the reason that accurate building is so critical. If anything is found, fix it.

Most gliders will have some pitch down at ignition and early boost, and gradually change to a pitch up condition near burnout. This results in an "S" shaped flight profile. If the deviation is minor, don't worry about it. A slight roll during boost will keep your glider headed in the right direction.

Models that have boost problems can often be helped with a longer and/or heavier pod. Extending the fuselage to put the motor farther in front of the wing also helps. A longer rod may help boost also, as will avoiding high winds when launching.

If the model pitches down severely under thrust, the pylon may be too tall or the thrust may be misaligned. If the model pitches up under thrust, the pylon may be too low, or the thrust misaligned. If the model starts straight, then starts pitching up, the wing lift is causing the problem.

8.2.12.1 How do I get the Estes Tomcat to glide?

I remember my first time judging a 4H rocket fair. I judged the advanced group, and the Tomcat was one of the most popular models. I could easily tell which models had already flown by looking for the mud and scratches on the nose cone. every one seems to have trouble with this rocket.

Note that there were two versions of the instructions - a bunch went out with a version of the instructions that would have you put far too much deflection in the elevators, i.e. double what's needed. A single shim from the stabilizer stock is what's required.

Here are some tips John Kallend posted to RMR back on
Tue, 2 Aug 94 18:31:38 GMT

"I have now had six "successful" consecutive flights with my latest Tomcat (successful means no repairs required). I find:

1) The C5-3 is far better than the C6-3

2) Don't angle the launch rod into the wind, launch straight up. Have the top of the model toward the wind - it will pitch "up" into the wind anyway. If all goes well it will arc over inverted, into the wind and then roll upright before the wings deploy

3) The model "flops" around on the launch pad unless you do something to stop it. I put another 1/8" music wire rod into the ground, parallel to the launch rod, to support the wing and hold the model steady before launch.

4) The model seems to suffer from spiral instability on the glide. This does not really show up on the test glides (because they aren't long enough) but both of my surviving Tomcats would drop into a steep spiral on the glide. Fixing this would require a major re-design. Be very careful that your stabilizers and vertical fins are well aligned. I also reinforced the front of the body tube to avoid tearing when the nose cone hits the ground first

5) Both of my current models came out heavier than Estes suggested weight. I don't know how I could have made them any lighter.

6) I think this model could really do with a low thrust D motor (say D6 or D8). Anybody know of such a motor in an 18 mm size?

jk

[Other reports indicate prangs on the Apogee D3 and shreads on the Aerotech D21. No reports yet on the Apogee D10 which might be just what John was looking for]

And from a former R&Der Michael Dennett: "The Tomcat prototype usually flew just fine in the hands of the designer. But it was marginally stable, and I also saw many of them spiral in during testing. It suffers from no dihedral, oversized vertical stabilizers (which generally results in tightening spirals once initiated) and if finished nicely, high wing loading. Mechanically it is an intelligent design."

...

And from the kit designer himself!

"Great care must be taken to balance for flight, balance side-to-side, and to make sure the wings are not twisted, and that the hinge works well. Prayer helps too."

8.2.13 My glider shredded. What is wrong?

It was either not strong enough, or the motor was too powerful. If the motor was too powerful, then the fix is obvious: use a less powerful motor next time. Beware of cored motors, they love to shred gliders. This includes the ignition spike of the A10-3, B8, C5-3, and almost all composites. A few composites, like the AeroTech/Apogee C4, D3, E6 and F10 are designed for gliders.

Also beware of violent ejection charges on fixed pod models. They can rip the pod off the fuselage. Some reinforcing across the fuselage, pylon, and pod will fix this problem. Also refer back to the discussion of grain

direction on pod pylons.

Sometimes the solution is as simple as ballasting the pod. Gliders are often under optimum weight, so adding weight to the pod slows the boost, increases the coast, can increase the final altitude, and is dropped off before glide. I often crimp a few fishing split shot to the shock cord to add weight to the pod.

There are several things that can be done to strengthen gliders. Spruce is often used for the fuselage to increase its strength, but at a significant weight penalty. Wings can be made of thicker wood, although this increases the weight of the glider. When trying to maximize performance, it becomes important to select the density of the balsa used in your glider. Lighter wood (6#/ft^3) will save weight, while denser balsa (10#/ft^3) is stronger. Use the lighter wood for wings and stabs, the denser for fuselages, which is still lighter than spruce.

You also need to consider the grain of the balsa. "A" grain wood has the grain running perpendicular to the surface. It is very flexible. It is not a good choice for wings, but is excellent for sheeting built up surfaces, or rolling balsa tubes. "C" grain wood has the grain running parallel to the surface. It has a mottled appearance, and is very stiff. It is ideal for wings and stabs. "B" grain is between A and C, and should be used where stiffness is not an issue, such as fuselages.

The SIG catalog is an excellent reference on the subject of balsa density and grain. The balsa information from an old SIG catalog can be found on the web at http://www.mentornet.org/balsa3.htm.

Higher aspect ratio wings are weaker than low aspect ratio wings. Try redesigning your wing or tail to lower the aspect ratio.

An excellent way to strengthen balsa without adding much weight is to tissue the glider wings. See below.

Two other ways to make lighter wings particularly on large gliders are built up construction, and foam cores. A wing can be built of balsa strips, and covered with tissue or Monokote. This can yield a very strong but lightweight wing. Foam is commonly used in RC models, and can be used in some of the larger gliders (C-D and up) covered with fiberglass or tissue. Uncovered foam from meat trays can be used for some mini-motor designs. These techniques are beyond the scope of this FAQ.

The leading edge of a wing is prone to nicks and dings from running into things. This can be reinforced with a thin strip of spruce, or a thin piece of nylon or Kevlar line glued along the edge.

For the ultimate in strength and low weight, all parts of a glider can be reinforced with composites like fiberglass, carbon fiber or Kevlar. This is applied either with Amberoid or an Epoxy resin.

I learned about composites from a book by Lambie, another by Rutan (yes, THAT Rutan), and from the MIT folks including Mark Drela. Mark set several indoor HLG records, worked on the Deadaelus and other human powered vehicles, and lots of other stuff that used balsa.

Mark's Upstart-4 can be found in the January 1981 issue of Model Aviation on page 52. It was probably one of the first IHLGs to feature carbon fibre.

8.2.13.1 How to tissue a glider

This is an art in itself. You will need some "Japanese" tissue (from SIG or Peck Polymers) and some clear low shrink dope. I have found that SIG Nitrate dope is less likely to warp the wings, and fills the pores faster. The tissue comes in assorted colors to decorate your model. Use 2 colors, with a darker color on the bottom, for visibility in the air, and a lighter color on top for visibility on the ground. Green is a poor choice for the top, but Blue surprisingly looks pretty dark in the sky. A couple primer coats of dope are applied to the balsa surfaces. Another coat is used to stick the tissue down to the balsa. More coats over the tissue soak through and bond the tissue to the balsa, and fill in the pores.

Brett Buck describes Tissuing Glider Wings in a bit more detail: "For MR sized models, Japanese tissue is probably the best commonly available choice. It's available from Peck-Polymers, and many other sources.

To apply, put several coats of just-thinned-enough-to-brush clear dope, Use SIG Nitrate, Brodak, SIG Lite-Coat, or in a pinch, Aero-gloss. DO NOT use SIG Supercoat - it shrinks too much. Let it dry 4-8 hours between coats, unless you're using Brodak (you only need to wait ~2 hours). When it starts getting getting slightly shiny, that's enough.

Cut the tissue slightly larger than the area you want to cover. The tissue has a grain to it. You can see it, but you will also note that it tears easily along the grain but with great difficulty across the grain. The grain should run along the long ways of the pieces, in this case spanwise. The tissue also has a top and bottom. One side is very shiny and hard looking and the other side is matte finished. Use the tissue shiny-side up.

Lay it down and smooth it out. Use it dry. Start in the middle of the area, and brush a very thin mix of dope and thinner (mostly thinner) from the middle out. It will run through the tissue and soften the underlying layers, sticking the tissue down. Smooth it out as you go, and if there's a wrinkle, put on a lot of thinner to loosen it up, and then lift the tissue and pull out the wrinkle. It's very strong, and difficult to tear, so you don't have to be too gentle. Once the whole area is covered, I like to go back over the entire surface with more thinned dope, let it sit for a few seconds, and then rub it down with a paper towel to really force the tissue into intimate contact with the wood.

If you need to go around a compound curve, wet the tissue with water just in that area, and pull away to stretch it around the curve.

Once you are satisfied with the covering, go around the edges of the piece with 220 sandpaper to sand into the tissue to cut off the excess. This is better than cutting it with a knife, since the slightly fuzzy edges stick down better. Then seal the edges with more dope. Then flip it over and repeat for the other side of the wing.

Once the whole thing is covered on both sides, put on a few coats of 50-50 dope. It will get more and more transparent for the first few coats. 2-3 should be sufficient, but 4-5 will make it very solid and can be rubbed out if you choose.

If the wing warps due to shrinkage, it can be straightened right after a coat of dope when it's soft. Once everything is dry, heat or steam will be required. Beware of heat guns, as dope (particularly nitrate) is highly flammable. For most thin glider wings, steam will work. For thicker wings (like 1/4" balsa") steam will not work. In this case, wrap the wing with a bath towel and then pour boiling water on the towel until it's soaked, let it sit for a few seconds, then twist against the warp for a few minutes. Then take off the towel. I had to do this just last week with my Ecee Thunder wings.

I'm sure others will add to anything I've missed. This is the traditional way of finishing any balsa part. If you want a good finish, this method saves a tremendous about of weight, because trying to fill bare wood grain with filler takes a lot more filler than than trying to fill tiny holes in tissue. Not to mention that the filler inevitably shrinks down into the grain after a while. It also adds a tremendous amount of strength compared to the negligible weight gain.

An alternative material that I prefer in a lot of cases is .2 oz/square yard graphite matte. This is available from Aerospace composites. Ask for "soft" matte vice "hard" matte. Soft fills more easily. Apply with dope in the same way (except for the water for compound curves). It goes around compound curves much more easily than tissue, and is much stronger. It's about the same weight once it's applied.

For larger models, replacing the jap tissue with various grades of silkspan is preferred. This is particularly true if you have large open areas. It's tougher and heavier than jap tissue and is applied wet. For almost any rocket purpose, OO silkspan is plenty enough, but there are heavier grades GM (Gas Model) or SGM (Super Gas Model). SGM is pretty tough stuff. All tissue-type products add tremendous strength to the part. Iron-on or synthetic coverings like Monokote, Solarfilm, Polyspan (polyester tissue) are all very soft and will not help the rigidity very much at all."

8.2.14 The pod stuck on my boost/glider and the thing crashed. What is wrong?

You've just been shot down by the "Red Baron". If the pop pod stuck, try sanding to loosen things up a bit. Or dust the mating surfaces with powdered graphite, Teflon, or even talcum powder. Check the action of the pop pod when deploying. Streamers or parachutes have a nasty habit of catching on things that you didn't want them to, like glider wings.

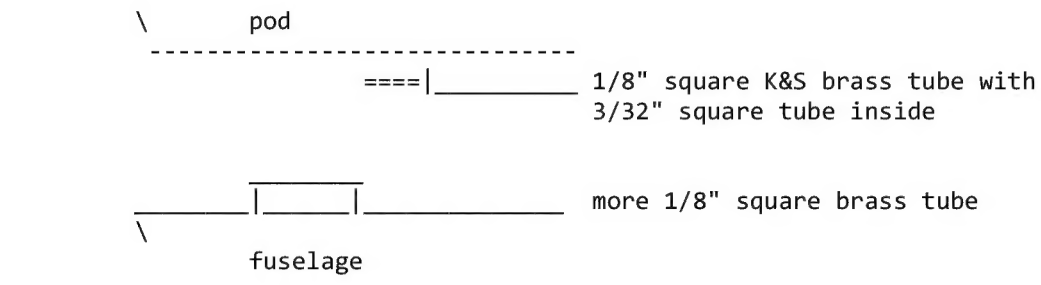
Sometimes fastening the recovery system to the pop pod in a different manner will prevent tangling. I use an external Kevlar line that is glued to the pylon root, but use strapping tape to fasten the line to the end of the tube just below the nose cone so the line is opposite the glider. That seems to help, at least for me. Ballasting the pop pod can also help, especially if ejection occurred long before apogee.

Some pop pod systems are specifically designed to prevent this problem, Try one of them.

One I favor particularly on smaller gliders is to skip the pop pod and go back to a fixed pylon like the old Sky Slash and Falcon. To keep it NAR legal, you tape a small streamer to the motor casing, and wrap it tight before installing the motor. Use a tube that is slightly loose inside to allow for the streamer.

A mid ejection two piece pop pod eliminates the string that is the common cause of the red baron. The down side is another small piece to have to search for.

In the mid 70's Greg "Fat Albert" Stewart published his "Baron Killer" pop pod. It shifts the motor back much like the original Astron Scout, and tumbles down. Small fins on the pop pod keep it legal for competition. He also used nested square brass tubing to attach the pop pod to the glider, a very positive attachment. Danger! bad ASCII art follows:



Another Red Baron proof pop pod is the shotgun cluster pod. Shotgun refers to an over and under or side by side cluster pod arrangement, so named because it looks like the business end of a double barrel shotgun. For B BG you use a cluster of 2 A3-4T motors. The bottom one (i.e. closest to the boom) is ignited on the pad. A 2" piece of thermalite in the nozzle of the top motor is stuck in the exhaust of the first motor. It ignites the second

motor just about when the first one burns out. About 3 seconds after that burnout, the first ejection charge fires, separating the pod, but deploying NO recovery system. Thus no red baron. A second later, after the pod has fallen free, the second ejection deploys a chute or streamer. It works very nicely, especially when the alternative is to go to a fatter and heavier motor casing (2 A3s vs a single B4). You can also cluster two motors of different delay, and ignite both at the same time.

You can also have the opposite problem, where the pop pod falls off too soon, sometimes under power. First check the fit. If it is too loose, use tape to make it tighter. This could also happen at launch, where the glider is blown off the pop pod by wind, or just after launch due to a structural failure. Use a Power Tower type launcher to fly a glider and provide additional support for the glider on the pad. Some pop pod hooks, like the molded Apogee hook, are designed to prevent premature glider separation.

8.2.15 My glider glides like the space shuttle (or worse). What is wrong?

Unless you are very good and very lucky, your glider will need several adjustments before it glides well. The process of making these adjustments is called trimming. The goal is to get a glider that transitions quickly and flies smoothly, gently circling overhead. If you are right-handed, you will probably have best luck trimming your glider to circle to the LEFT. If you are left handed, reverse all the following references to left and right.

All trimming is done with the model in glide configuration. For a BG, this means without the pod, For an RG, it means with a spent motor casing installed, and wing, pod, or whatever deployed as it will be in gliding flight.

The first step in trimming is to locate the CG at the proper position. If you are lucky, the instructions or plans will tell you where to locate the CG. If not, you will need to compute the Neutral Point (CP), or use a typical location like 1/3 of the wing chord from the leading edge. Gliders are often tail heavy. Add weight to the nose if necessary to get the glider to balance 10-20% of the wing chord in front of the NP.

All the rest of the trimming should be done by controlled warping of the flying surfaces. Start by getting the model to glide straight, which is much easier if it was built without any warps. In an open area gently toss the glider forward, releasing it with both the wings and fuselage level. Note its action. If the model dives (drops its nose), warp the stab trailing edge UP a bit. If the model stalls (noses up, then suddenly drops, often straight into the ground) warp the trailing edge of the stab DOWN a bit. The best glide us usually right on the edge of a stall.

I like to warp both wing tip trailing edges up to prevent tip stalls, and the center portion of each wing down to increase the wing lift.

Then add a left turn until the model has a slow flat circular glide. Some turn is often added during construction by tilting the wing in the direction of the desired turn, or tilting the stab in the OPPOSITE direction. Turn can be increased by warping the trailing edge of the OPPOSITE wing down a bit. I try to avoid warping the inner wing panel trailing edges up at all, as this can lead to spiral dives. Turn can also be adjusted with the rudder.

For a left roll on boost, warp the left tip of the stab trailing edge up, and the right tip down. This works at high speed, but has little effect at glide speeds. Use wing warp, stab tilt, and a bit of rudder to increase or decrease the turn as needed.

Try a few harder throws. The glider should quickly settle down into a flat gentle circle. Continue adjusting the surfaces until you get this result.

Now you are ready for a serious hand launch. This is an art form in itself. Throw the model up as hard as you can, at a 45 degree angle up and to your right, and with the wing banked at the same 45 degree angle. The model should slowly roll to the left, changing from a right turn to a left turn. If you are lucky, the model will be gently circling 30 or more feet overhead. If not, it probably smacked the ground, so pick it up and try again. Go back and check the trim with a gentle toss, and if all is OK, try again. You may want to vary the angles between 30-60 degrees each, until you find what works best for you and your model.

Now you are ready for the first launch. Pick a reduced power motor, just enough to get the glider to a reasonable altitude, and launch it. Use a power tower as described previously. Carefully observe the boost, transition, and glide. Watch out for a "death dive" where the glider never transitions and comes straight down. This can be fixed with increased stab incidence or warping the trailing edge of the stab up. Also watch for "spiral dive" where the model turns very tightly and crashes into the ground. This is caused by too much turn, or a wing that isn't producing enough lift. Try reducing the turn or warping down the inside edge of the inboard wing.

Continue to adjust the flying surfaces until you get the flight you want. Now move up to the desired motor size, and fly again. Soon you'll need to read the answer to the next question.

Trimming can be very difficult in humid climates! At NARAM-30 in Huntsville I had a hard time trimming my gliders. I'd toss one, then recover it and make an adjustment. Toss it again, and it was better. Pick it up and toss it a third time and it was just like the first toss. ALWAYS made sure that models were well doped before trying to trim them, and do so before going to a humid climate.

Of course, there's my NARAM-42 BGs. After building them, took the pair out to the back yard, and gave each one a couple tosses, just to see how they did. DEAD ON in trim. Spend some time in Canon City futzing around with one,

and accomplished nothing but making it worse! Put one in a little thermal (nothing like my ELD model) and easily did 2 minutes on an A8-3. The same model won B BG at NARAM-44.

Kevin McKiou's trimming advice:

1. Make the dihedral 15 degrees!!!! Last year I had prototype which just would not trim out. It did death dives. It would go inverted at the top of the hand launch (HL) and go inverted into the ground. It did all kinds of crap I could not figure out. The dihedral was set at 12 degrees, which was plenty for spiral stability, but not enough to make it really stable in the transition on a HL. All I did was increase the dihedral to 15 degrees. After that, it was easy to trim. It would roll out like a champ at the top of the HL.

2. Make the distance between the wing 1/4 chord and the tail 1/4 chord about 50% of the wing span. This will be adequate for spiral stability, but not excessive.

3. Make the horizontal stab area between 15% and 20% of the wing area. When I have gone below 15% I have had problems with excessive elevator deflection required. Anything above 20% is unnecessarily draggy.

4. Make the vertical fin area half the horizontal stab area.

5. If you can calculate the neutral point, set up the CG so the glider has a 15% static margin as a starting point. If this works out, fine. It is probably close the the safe minimum. If you can't calculate the static margin, start with the CG at about 40% back from the leading edge at the wing root.

6. Trim the elevator so the glider *just* will not fly in a straight line without stalling, no matter how slow you throw it. Remember to always toss it at a point on the ground about 20 feet in front of you.

7. Now you want to induce a turn. Add about 10 degrees of horizontal stab tilt to the right to induce a left turn. Add about a half gram of clay to the left wing tip to get the turn started. Give it another slow toss slightly down. If it glides into a left turn that is pretty flat, you are very close to perfect. If it turns too fast, remove to tip weight. If it won't break into the turn, add a touch of left rudder.

8. Time to throw it. Throw it up at about a 60 degree angle and tilted slightly to the right. It should arch up, go briefly inverted at the top and roll out in the opposite direction from which you threw it. Give it a real firm throw.

If it kind of slid up and did not arch back, you have the CG too far back. Add half a gram of clay to the nose and go back to step 6.

If it definitely looped back on you, try again with a throw that is a little more horizontal. If you just can't get much height because it wants to loop back (usually into the ground), the CG is too far forward. Remove a bit of nose weight and go back to 6.

If it seemed to launch OK and pretty much stalled at the top with a really slow roll out, add just a bit more weight to the left wing tip and/or a touch more left rudder.

9. The glide after HL should be a big gentle circle to the left. If you are not getting a turn, but the launch looks good, give it a bit more left rudder. That should help it into the turn. If the model tends to glide too fast in the turn, add a bit more up elevator. If it seems you just can't get everything working quite right between the launch and the turn (e.g., glides fine, but wants to loop on HL) add wash-in to the left wing tip. That is, bend the trailing edge down on the outter 1/4 of the left wing. Now, as the speed builds, the lift of the outter portion of the left wing wing increase more than the rest of the wing and forces it to straighten out the glide a bit, slowing it down. As the model slows, the wing tip weight and rudder will tend to turn the model back into the turn. Now you can back off a bit on the elevator. Use this sparingly. You can over do it and cause the model to tip stall. If the glider builds speed as it glides, with no real recovery in a second or two, the CG is very likely too far back. Add a half gram of clay to the nose and go back to 6.

That's about it. From this point, you will just have to try it, varying each of the parameters to get a feel for what works well. If you work this well, you should get very good hand launches and transitions to glide.

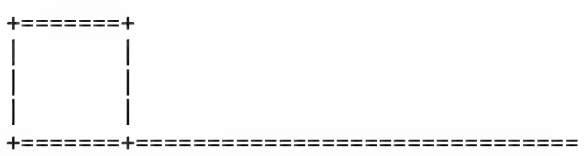
-Kevin McKiou
1994, 1996 US Spacemodeling team member

visit the Vectoraero website (http://members.aol.com/kmckiou) for RC Rocket Glider kits and free plans

visit the US Spacemodeling website (http://www.spacemodeling.org) for info on competition model rocketry.

Comment from Bob: I don't know if Kevin tried anything between 12 and 15, but I've been using 14 for many years. Why 14? Well, it's actually 14.0362... Which is the arctan of .25. It's simple to lay out. Build a right triangle that is 4" on the base, and 1" high. That's a 14 degree angle. I use that guide to build my dihedral joints. It works for Micro Maxx or D sized models.

Here's a crude drawing. If the block is 1" high, then the extension is 4". By making the base of 1/2" plywood you've got a good sized backstop for a sanding block to sand the dihedral bevel into the wing root.



8.2.15.1 How do I trim a Flexie?

Flexies are very different to trim. I refer you to the master, George Gassaway:

From: gcgassaway@aol.com (GCGassaway)
Subject:Re: Newbee Flex-Wing BG questions Date: 12 Jan 1999 06:43:05 GMT

There is a trick to making flex-wings have good pitch stability without having to resort to other tricks such as tails, canards, and weights.

About 20-25% back from the nose, use some very sticky tape such as a strip cut from a band-aid (I use some good old sticky adhesive mylar but that's not easy to find). Use the tape strip to pull the plastic taut into the spar and another piece to pull the plastic taut into the right spar. The remainder behind should be allowed to drape loosely so it billows with air when it glides.

Since you will need to experiment, do not attach the tape down permanently until you get the tautness just right for a good glide trim (I usually only have a small portion lightly stuck to the plastic, with the rest of the tape strip peeled up into the air). After all, if you use the kind of thin plastic as I use (1/4 mil dropcloth) once the tape is down good you will rip the plastic before the tape will come up if you later want to try to adjust the tautness and billow.

When the tautness and billowing are right, the taut front end acts as a built-in canard, sort of like having a flying wing that has elevators on the inboard leading edges instead of on the trailing edges (not that I can think of any real flying wings that were like that). I won't get into it any deeper since it is mostly just a matter of trying it and adjusting it until it glides stably. Once you get in the ballpark, you can tell, though if stalling persists you might need to add a little noseweight too (clay falls off too easily, I often glue a scrap piece of spruce or something else, even a piece of solder, to the nose center spar to move the CG a bit forward). But you can experiment with clay at first to make sure it is a CG problem before gluing anything. Sometimes to get a good stable glide I've allowed one side to billow a bit more than the other, making the flex-wing glide in a turn of about 10 feet in diameter. But too much billow on one side can make it tend to spiral down. Again trial and error in learning will teach far more than I could type about it.

Now, canards can do the job but they add extra complexity and difficulty. Takes a lot less time to find out how to trim by this nose tautness and rear billow method than do any actual design changes....which you would also still have to learn how to trim out anyway.

More flexie trimming information can be found at
http://www.wizvax.net/jvincent/sd/sd980102/fw1.html and in NARTS publication NIRA4 "Glider How-To Articles from the Model Rocketeer" for $3.50

8.2.16 My glider never came down and flew away. What is wrong?

If it went in a straight line, you need to re-trim the glider to circle as it glides. Perhaps your field was too small. Find a larger place to fly.

If neither of these is the case, you probably just found a thermal. Air is not static. It moves around due to uneven heating and cooling. A hawk circling overhead, without flapping its wings is in a thermal. When air is heated, it rises. When air is cooled, it sinks. Whatever is in that air goes up or down with it, be it bird, balloon, rocket, or airplane. If the air is rising faster than the sink rate of your model, the model will rise in the air. In general, this is good, as it allows your model to fly much longer. It stops being good when you lose the model!

This is a "good" problem. It means you've solved most of the problems you've encountered, and have (had?) a pretty good glider. Picking thermals is an art that is beyond this FAQ (but we'll try anyway, shortly). Now we have to find a way to get the glider back. These devices are called dethermalizers (DT) because they are designed to get your model out of a thermal.

This is done by transforming a good glider into a bad glider. There are two parts to this transformation. The first is some sort of timer, to cause the action to occur when you choose. The second is an actuating device that de-stabilizes the glide.

Timers come in several forms. Most common is dethermalizer fuse. This looks more like cotton rope, and burns very slowly, typically 1/4" per minute. By having this fuse burn a string or rubber band, we can actuate a device in flight. Be sure to use a snuffer tube (short piece of brass or aluminum tube the extinguish the burning material) with the fuse, to prevent the fuse from falling free and starting a grass file. Other more sophisticated timers are built from small spring wound motors, or a viscous fluid like STP or silly putty with a piston slowly moving through the fluid

http://www.mindspring.com/~thayer5/ffpages/tips/timer/putty1.gif
http://groups.msn.com/FreeFlightOnline/interestingstuff.msnw?action=ShowPhoto&PhotoID=62
http://homepage.interaccess.com/~ndzied1/Detherm/Open.jpg
http://homepage.interaccess.com/~ndzied1/Detherm/Closed.jpg

Some are even electronic

http://www.geocities.com/rdh82000/Picoalt/index.htm.

There are many actuating devices used. The simplest is a drop weight. Since we often need to add weight to the nose of a glider when trimming, this weight can be dropped, with a string going either to the tail or INSIDE wing (if you go to the outside wing, all you will do is change the glider from a left turn to a right turn, or vice versa). By shifting the weight, the glider will now severely stall (tail), or spiral (inside wing) into the ground.

The "beer can" DT was popular at MIT because of its first step, empty a can of beer! A piece of the aluminum can is deployed as a flap from the INSIDE (turn side) of the fuselage. This acts as a drag break, and causes the glider to slowly spiral down.

Often a DT consists of a flap, either on the wing or stab, that pops up and alters the trim of a glider, causing it to spiral dive or stall. One problem with these is that if not set properly, they can mess up the trim of your glider, eliminating the need for a DT in the first place.

Another problem with many DTs, especially those that produce a stall or gentle spiral, is that in a strong thermal, they may be insufficient to recover the model. Finally, the DT action may bring the glider down so hard that it is damaged on landing.

I like the pop up wing DT used on the Gold Rush (see reference below). The entire wing is hinged, and pops up about 60 degrees. This effectively turns the entire wing into a drag break, sending the fuselage straight down. The model lands nose first, protecting the delicate tail from damage. A variation of this totally cuts the wing loose, except for a string that ties the wing to the tail. The fuselage falls like an arrow, nose first, with the wing fluttering behind. Another nice feature for the serious competitor is that the hinge pin can be removed, making the model very easy to pack for shipping.

8.2.16.1 So how do I find a thermal?

From: Mike Dennett

"Anyone interested in learning about thermals will find some good reading in a copy of Dave Thornburg's "The Old Buzzard's Soaring Book". It describes how model fliers can predict the patterns of thermal activity, and contains lots of easily read material on the behavior of air in general.

http://www.fatlion.com/sailplanes/releases.html

is one source I found that lists them for sale.

Your description of the wind picking up again would indicate to me that the lift is just downwind. The best seat of the pants indicator I have found is the sudden warm, calm period (like you mentioned) that may be first accompanied by a gentle flow of air in the opposite direction of the prevailing breeze depending on its strength. That air is headed upwind to the core of the thermal and then upwards. Good time to toss that hand launch glider right about then. Or push the button. I imagine air headed radially inwards towards the core from all directions, like a great vacuum cleaner nozzle has descended from the sky and is traveling with the prevailing wind direction."

Another article I found is at
http://www.f4bscale.worldonline.co.uk/Thermals.htm

Peter Alway writes in his unique but colorful style: "Bumbling into Thermals: How to make your rocket go up after the parachute opens

It's all connected. The rolling of noodles as your soup comes to a boil, the puffy clouds on a hot summer's day, the fine granulation on the sun's visible surface, the slow grinding of continents, and the miracle of a model rocket drifting up and away, never to be seen again. All are examples of convection, a process that transports heat from the bottom of a fluid upward. One sort of convection, called a thermal, is the key to success in model rocket duration competition.

The NAR sanctions dozens of model rocket meets every year. Each meet offers an assortment of events: spot landing, altitude, craftsmanship, and duration. Duration events are popular because the participants can score them objectively with nothing more than a stopwatch (Actually two watches and two timers to operate them for each flight to improve accuracy and to provide backup in case of a blunder). A contestant in a duration event is usually worried about three factors: Weight of the model, aerodynamics of the model, and air. Obviously, a lighter model will fall more slowly. Aerodynamics can be as subtle as a glider's airfoil, or as simple as a parachute's diameter. Only after the modeler builds and preps the model does he worry about air.

The holy grail of duration flying is catching a thermal. Thermal is a flier's term for the rising, warm air of a convection cell. You may have seen a convection cell in a pot of soup heating up. As the stove heats the bottom of the pot, the soup at the bottom warms up and expands, becoming less dense than the cold soup above. The heavier cold soup falls to the bottom, and the hot soup at the bottom rises. The soup at the top loses heat to the air, cools, and becomes more dense, the soup at the bottom is heated and becomes less dense, so the process repeats. In fact the process continues steadily; the soup constantly turns over. Depending on the details of the pot and the stove there will be a continuous upwelling of soup in the center of the pot, and a continuous sink at the edges (with my gas stove and a small pot, I actually get an upwelling at the edges and a sink in the middle, but the process is the same).

Even though the sunlight that heats the Earth's atmosphere comes from above, it warms the air near the ground from below. The sunlight passes through clear air unhindered and heats the ground. The warm earth then transmits it's heat to the air. Warm air near the ground heats up, expands, and becomes less dense than the cool air above. The cool air sinks, pushing the warm air up, and creates a convection cycle just like the one in the soup pot. But without noodles, so you can't see it. Your task as a duration modeler is to inject your rocket into the thermal, the warm, rising air in the convection cell.

Not all thermals are created equal. Some are stationary, hanging over dark asphalt roads, parking lots, or roofs. Others roll along with the wind. Some are weak, some are so strong they become 'dust devils' that can pull the hat off your head. Some are tiny, some grow so high that you can see their tops in the form of puffy cumulus clouds. Thermals tend to be weak at dawn, and grow stronger and more frequent on a sunny afternoon.

You have probably felt thermals without realizing it. If you've been out on a hot day, you have probably felt the relief of a cool breeze out of nowhere. That's the down draft of a convection cell, the 'sink' of a thermal. That's exactly what you don't want to launch into. But what do you want to fly into? How can you detect a thermal?

I confess that I'm not the world's best thermal spotter, but I have techniques that are better than flipping a coin, and I have seen some tricks that others use. They are a mix of rendering thermals visible and detecting them by feel.

Some folks use a pole with a ribbon. They attach a 10-20 foot length of audio cassette tape to the end of a 10-foot bamboo pole. As the tape blows in the wind, they will watch for a moment where the wind lifts the tape above the end of the pole. The updraft is a thermal, and that is their signal to launch. I'm not sure that most thermals have really formed at just 10 feet up, but then again, the ribbon-on-a-stick folks tend to beat me in competition.

Some people prefer a bubble machine to put some 'noodles' in the soup of air that surrounds us. The principle is the same'rising bubbles indicate rising air.

Other modelers build little weather stations' a sensitive electronic thermometer connected to a computer that records the pattern of rising and dropping temperatures. When the high is 5 degrees over the low, you've got something, and you launch. Immerse yourself in a combination of these devices and you will learn to see thermals coming.

I've heard of the manly rocketeers who took their shirts off at launches so they could feel the wind at their back and find thermals that way. Naturalists will trust hawks and turkey vultures who love to circle in thermals, feeling them out by the lift and warmth under their wings.

As for me, I use a strategy that is cheap, simple, and modest. I fly with my brother, Bob, in a team called the Bumbling Brothers Flying Circus. While Bob prepares his model and sets it on the pad, I pay attention to wind and heat. It's hard to ignore the wind, but I also notice the little warmings and coolings. Once the model is on the pad, I ask myself 'is it windier than average at this moment?' If it is, we wait. I ask myself 'Is it warmer than average right now?' If it isn't we wait. I rarely wait for more than five minutes. It's a tough call, and I don't always get it right, but eventually, the wind lets up, and I feel warmth.

I have a pet theory that the real lift hits at the end of the calm interval. My theory is that the wind that comes blowing in has to go somewhere, and the only place to go is up. At least one experienced flyer has laughed at that one, so I might be full of nonsense. But at more organized contests where everyone flies from a rack controlled by an RSO, that's a moot point, because the process of getting the model off the ground can take so much time that you are almost always at the end of the calm interval.

I'm ready, you call to the RSO

Modeler's ready on pad five.

Timers ready?

Yeah we're ready.

OK, pad is ready with a an A8 is that an A8-3?

Yes it's an A8-3. I'm ready! you answer as you nervously feel a little gust coming.

OK, ready on pad five. Oops do we have continuity oh the switch was on pad four. We have continuity now. Timers ready? Yes we're ready

Modeler ready?

Yes! Yes! Fly it now! The breeze is starting to pick up is it starting to cool down? Oh Kay. A eight three on pad five. Ready?

You can feel the thermal rolling past.

Fiiiivveee. Fffooooouurrrr. Threeeeeeeeee. Twooooooooo

How can anyone count backwards so slowly! I'm losing my air

Ooooonnneeeee. Zeeeeeerrrrrooooo. Lllllaaaaaauuuuucccchhhhhh!

Whoosh. Pop. Unfurl Unfurl Unfurl Blossom.

It is satisfying to see a big silver parachute pulsate like a jellyfish as

it opens in a thermal--It's going up!

I love to watch a model rise on a parachute. It's almost like watching a hot air balloon in flight. Sometimes the model goes forever, or at least it rises until it is out of sight. I have seen parachute models disappear into the bases of clouds. I have seen them float for half an hour. I will never forget Bob Kaplow's NARAM egglofter that hung for half an hour over the Pennsylvania mountains (coincidentally formed by the ancient collision of crustal plates propelled by convection currents in the Earth's mantle) before flying away beyond the horizon. Boost-gliders also can stay up for many minutes under a thermal. Even a streamer model will catch a little lift off a thermal and stay up longer than you might expect.

Thermals are a wonderful wild card in contest rocketry, though you can't thermal away a model that sinks too fast'you need a light rocket with a lot of wing or parachute area to catch an express elevator in the sky. Also, you have to recover a model in each duration event if you want those miraculous anti-gravity seconds to count.

Every part of model rocketry can be an opening on a new world. Scale modeling has introduced me to the history of spaceflight and a deeper understanding of design. Predicting rocket altitudes as a teenager prepared me for calculus. I have come to see searching for thermals as a way of understanding the motions of invisible air, like those wonderful cool breezes. Recently, while visiting a local nature preserve, I saw a bald eagle flap into the air, and then circle effortlessly upward out of sight. Thanks to my experience finding thermals at rocket duration contests, I could appreciate exactly what he was doing. When you catch your first thermal, you might just feel like that eagle, a master of the air."

8.2.17 Glossary: (with thanks to AstronMike@aol.com)

Airfoil: Cross section shape of the wing surface. Glider wings are rarely symmetrical, and for our models are mostly flat bottomed.

Angle of Attack (AOA): The angle of the mean chord line with respect to the airflow, with zero AOA being defined as the zero lift angle of the wing. More simply, it's the angle the wing hits the air.

Angle of Incidence: The angle between the wing and the thrust line.

Aspect ratio: The ratio of wing span to wing chord. AR = span^2 / area
Higher numbers tend to be more efficient, but can be weaker.

Canard: A glider with the stab in front of the wing. These usually have very good stall characteristics. They appear to be built "backwards".

Chord: The maximum front to back length of the wing, usually the root where it is attached to the fuselage. Also used Root chord, Tip chord.

Decalage: The amount of angle that the stabilizer is tilted from the angle of the wing. This angle is usually slightly negative, either leading edge down or trailing edge up. Used to give a very slight up elevator pitch to the glider and help it recover from dives.

Dihedral: The amount the wingtips are raised from the wing root. Used to keep the model roll stable in glide. A typical free flight model will have about 15 degrees of dihedral, or about 1" for each 8" of span. Trihedral is when you have three wing sections, the center section being horizontal. Polyhedral is when you have four or more wing sections at different angles. Anhedral is when the tips are pointed down, occasionally found on the stab.

Dive: When the nose of the glide drops in flight.

Fuselage: The glider body, usually a stick.

Incidence: see Decalage.

Laminar: smooth air flow over a wing with no disturbances. Not turbulent.

Lift: Upward force created by airflow as it passes over the wing.

Neutral Point: Is the glider CP.

Pitch: The rotational axis where the nose moves up or down. If you make a "gun" with your hand, then extend your middle finger straight out, you have the three axis of a glider. The middle finger is the pitch axis. The index finger is the roll axis. And the thumb is the yaw axis.

Reynolds number: A dimensionless number which describes the type of airflow over a wing, also used to scale wings for wind tunnel testing. The formula for it is: Re=density(air)*velocity*length(chord)/viscosity(air). Re for our models typically are under a million and are considered the very low Reynolds number region.

Roll: The rotational axis where the glider leans towards one side or the other.

Span: The distance from one wing tip to the other.

Stabilizer (stab): the horizontal part of the tail.

Stall: When a wing suddenly loses lift. When this happens, the glider will first nose up, then the nose will rapidly drop and dive.

Sweep: The amount the leading edge of the wing angles back from the wing root. Sometimes the sweep will be negative, and the tip is actually swept forward.

Tail spin: An antiquated term for what we refer to now as a "spiral dive". It is not related to a stall or spin in any way. When this model suffers a problem, it typically is a spiral dive, which can result from grossly unequal angles of incidence between the tip sections on either side, or excess noseweight, or both. (RobEdmonds)

Washin: The amount the wing trailing edge is bent down. This increases the lift of this portion of the wing.

Washout: The amount the wing trailing edge is bent up, relative to the leading edge. Not dihedral, but actual fore/aft warpage, usually to keep whole wing from stalling at once. This decreased the lift of this portion of the wing.

Wing Loading: Ratio of wing area to glider weight.

Xerclod: The name given by the MITrs to the pod hook referred to by Stine as "piece X".

Yaw: The rotational axis where the glider turns left or right.

8.2.18 References: (kits, books, publications, catalogs)

Kits:

ARG		Floater 30 Floater 60
Apogee		Maxima pod hook End burning composite motors [Apogee carries some Edmonds and Holverson glider kits]
Eclipse		???
Edmonds		CiCi Deltie Deltie-C Deltie Thunder Ecee Ecee Thunder Geminee Geminee Thunder Ivee Ivee-C Tinee
Estes	[Refer to the JimZ web site for out of production plans http://www.dars.org/JimZ]	
	#2075	ARV Condor
	#2097	Manta
	#1284	Space Shuttle
	#2086	Tomcat
	#2112	TransWing
Holverson		Silver Hawk Flying Wing BG 13 mm Swinger Swing Wing RG 18 mm Zoomie Flying Wing BG 13 mm
MRC		Thermal Hawk
Nano Rocketry		tba
QCR		Auta Sight FWs Easy Slide RGs Folded Wing RGs Never Loop BGs [QCR carries some Edmonds kits] Dethermalizer kit
Quest	#3002	Aurora
	#3006	Flat Cat
Shecter		Hornet Boost-Glider Shadowcat with Parasite Boost-Glider
Vaughn		Buzzard

Rocket Plans:

Dozens of classic kits and plans from old Estes and Centuri catalogs and newsletters are available on the JimZ web site at
http://www.dars.org/JimZ

Name	Class		Source
Barber	A BG	Pop Pod	SR Sep/Oct 1996
Beaker	B BG	Canard Pop Pod	NARTS #NIRA1 $3
Challenger 1	A BG	Pop Pod	NARTS #NIRA2 $3
Confederate Angle	A BG	Pop Pod	NARTS #NIRA2 $3
Czech Micro Glider	micro	Fixed Pod	http://members.aol.com/GCGassaway/GENERAL/Czechmicroglider.GIF
D-Light	D BG	Pop Pod	SR Nov/Dec 1997
Dragonfly	A BG	Pop Pod	JimZ
Eiger	4 BG	Fixed Pod	http://www.nar.org/competition/plans/pdf/eiger25.pdf
Filly Willy Flim Flam	B RG	No moving parts	NARTS #NIRA2 $3
Flanigan Flyer	B BG	Pop Pod	NARTS #MIT-CN $5
Fly Baby	C BG	Pop Pod	NARTS #NIRA2 $3 http://www.nar.org/competition/plans/pdf/flybaby.pdf
Flying Jenny	A BG	BiPlane	JimZ
Fish & Chips	2 BG	Pop Pod	NARTS #MIT-CN $5
Gull	C RG	Swing Wing	http://www.nar.org/competition/plans/pdf/gull.pdf

High Performance Sparrow	A	BG	Pop Pod	NARTS #MIT-CN $5
Icarus X	B	BG	Pop Pod	NARTS #NIRA2 $3
Jabberwock 15	A	RG	Slide Wing T	http://www.nar.org/competition/plans/pdf/jabberwock15.pdf
Julie Bird 7	A	RG	Slide Wing Box	http://www.nar.org/competition/plans/pdf/juliebird7.pdf
Lumb Duck	B	RG	Slide Wing T	NARTS #MIT-CN $5
Lumb Duck 4	B	RG	Slide Wing T	MR 3/80 pg 8-9
Manta (CMR)	C	BG	Pop Pod	SR 3/97 pg31
Millenium Falcon	A	BG	Fixed Pod	NARTS #NIRA1 $3
Nighthawk	A	BG	Flying Wing	JimZ
Nocturne	B	RG	Slide Wing T	http://www.nar.org/competition/plans/pdf/nocturne.pdf
Nymph	2	RG	Slide Pod	NARTS #MIT-CN $5 http://www.nar.org/competition/plans/pdf/nymph.pdf
Olympia 67	4	BG	Fixed Pod	http://www.nar.org/competition/plans/pdf/olympia67.pdf
Opel	-		FlexWing	MR 2/80 pg6-7
Parksley Eagle	A	BG	Pop Pod	NARTS #NIRA1 $3
Pterodactyl	F	BG	Parasite	JimZ
Rebel	A	RG	Slide Wing Box	Apogee 12/75
Rocky Mountain Canary	A	BG	Pop Pod	MR 3/79 pg6-8 http://www.nar.org/competition/plans/pdf/rockymtcanary2.pdf
Seagull 25	A	RG	Slide Wing Box	http://www.nar.org/competition/plans/pdf/seagull25.pdf
Seattle Special	B	RG	Slide Wing Box	NARTS #NIRA1 $3
Spittoon	B	BG	Pop Pod	NARTS #NIRA2 $3
Status-4	A	RG	Slide Wing T	SR Winter 1995 http://www.nar.org/competition/plans/pdf/status4.pdf
Stiletto-B	B	RG	Slide Wing T	http://www.nar.org/competition/plans/pdf/stilet-b.pdf
Stiletto-C	C	RG	Slide Wing T	http://www.nar.org/competition/plans/pdf/stilet-c.pdf
Stiletto-D	D	RG	Slide Wing T	AmSpam May 1985 http://members.aol.com/RBGliders/Stiletto_D.htm
Stinger	B	BG		AS 7/90 pg23-25
Swift	B	BG	Pop Pod	JimZ
Tapeworm	F	BG	InternalParasite	NARTS #NIRA1 $3
Turnup	A	BG	Pop Pod	SR Fall 1995 http://www.nar.org/competition/plans/pdf/turnup.pdf
Vincent	4	BG	Pop Pod	http://www.nar.org/competition/plans/pdf/gnatrecordholder.pdf
Wasp	A	BG	Pop Pod	MR 12/70
Wolf	C	BG		SR Summer 96 pg29-30
Wun	B	BG	Pop Pod	NARTS #NIRA2 $3
Xebec 3A	A	RG	Pop Elevator	http://www.nar.org/competition/plans/pdf/xebec3a.pdf
XP-2B	B	RG	Swing Wing	http://www.nar.org/competition/plans/pdf/xp-2b.pdf
XP-2C	C	RG	Swing Wing	MR 1/80 pg6-7 http://www.nar.org/competition/plans/pdf/xp-2c.pdf
XP-3	C	RG	Swing Wing	AmSpam 7/92 pg21 & NARAM92 pg24

HLG Plans:

Name	Source	Size	Type	By
Arriba:	MA 5/94 p??#759	??	Catap	Jean Andrews.
Athena *	FF 11/90 p17 $3	24"	HLG	Mark Sexton #
Big Shooter	FF 01/95 p6	18"	Catap	Bienenstein
Bolo	FF 10/94 p5	18"	OHLG	
Built-Up-Glider	NFFS $3		HLG	John Thornhill
CalCat IV	FF 12/94 p19	17"	Catap	Calvert
Canned Heat *	NFFS $4		Jetex	Don Chancey
Catelliptic	FF 10/97 p13	18"	OHLG	Bennett
Catharsis	BH-151	16"		Bill Hannah
Challenger	MA 8/85 p67	18"		
Class A Glider	FF 12/99 p4	12"		Midwest kit
Class B Glider	FF 12/99 p4	19"		Midwest kit
Coot VI	NFFS $3	19"	IHLG	Mike & Stan Stoy flapper
Copper Head	FF 11/98 p12 $3	19"		Stan Buddenholm
Crowbar 13	FF 06/95 p17	13"	Catap	Sonesen
Drifter 13	FF 01/00 p5 $3	13"	Catap	DeShields
Drifter 18	FF 03/98 p19 $3	18"	Catap	DeShields
Flash *	NFFS $3	17"	HLG	Fast Richard Mathis
Flip	#FF-14	14"		SIG kit $3.95
Fluf-Duf *	NFFS $3		IHLG	Dan Belieff
Fly Baby	FF 03/91 p7	14"	B BG	Russell
Fly Hi	NFFS $3	HLG		
Gil's Glider	FF 03/98 p5	12"	Canard	Coughlin
Gold Rush	MA 5/86 p64	24"		
Good IHLG	NFFS $3		IHLG	Don Bal
Heat SeekerMkIV	NFFS $4		Jetex	Kem Whiting
Jet Tube	NFFS $4		Jetex	Richard Woods
Jupiter Moon	FF 10/00 p5 $3	21"	HLG	Edward R Berray
Little Shooter	FF 01/95 p5	12"	Catap	Bienenstein
Lo Tech	FF 05/86 p7	14"	IHLG	Mike Reves flap
Lunchbox	FF 06/86 p3	9"	OHLG	Oldencamp
Lynn-2	FF 06/91 p15 $3	20"	HLG	Kimball
MIG-29:	MA 4/92 p??#713	13"	Catapult	
Mach Box	BH-129	11"	Jetex50	
Max Flyer *	NFFS $3	??	HLG	Ray Harper
Max Pak	FF 10/96 p5	32"	Catap	Primbs
Merlin 2	NFFS $3	18"	HLG	Wiese (Campbell's kits)
Micro-Mini Pearl	NFFS $4	26"	Jetex	Stan Smith #
Nickel Glider	FF 01/93 p21	13"	IHLG	Johnson
One Up	FF 05/88 p5	18"	Catap	Lorbeicki
Padre's Passtime	FF 11/97 p23	20"	Catap	Johnson
Paper Glider	BH-193			Jetex
Paragon	MB6/77p60 #6773	18"		
Pig Skin	FF 11/98 p13 $3	18"	HLG	Stan Buddenbohm
Pigeon	#FF-13	12"	SIG kit	$3.95
Plane Jane	NFFS $3		HLG	Mark Valerius
Polly *	FF 01/97 p14 $3	18"	OHLG	Bill Blanchard MA May 1979 page 50 #263 #
Priceless Fun	FF 02/98 p18	12"	toy	Billings egg crate lid
Punk Rocket	FF 06/97 p5	18"	Jetex	Tomasch
Quantum 20	FF 12/97 p8	20"	IHLG	Surtees MA 5/98 #853
RPG	FF 10/95 p15	15"	Catap	Sonesen
Rain Crow II:	MA 1/83 #394	??	OHLG	
Roll Out	MA ?/?? #201	18"	OHLG	pop-up dethermalizer
Roscoe 18	MA 5/86 p60#509	18"	OHLG	DT
Semi Pro	MA 1/76 p22#124	17.5"	OHLG	pop tail DT
Shockwave *	NFFS $3	??	HLG	Lueken
Sir Gruntalot	FF 05/98 p12	24"		Stalick
Slow Poker III	FF 12/96 p7	24"	IHLG	Budenholm MA 6/92 #716
Stealth Glider:	MA 5/91 #688	10"	Catap	foam/balsa combo.

Step Two	FF 04/91 p26	15"	HLG	Edmondson
Stomper	MA 5/86 p60#510	18"	OHLG	DT
Sub Sweep	FF 05/88 p6	12"	Catap	Markos
Super Sweep 22	NFFS $3	22"	IHLG	Wittman
Suz Too	NFFS $4	??	Jetex	Lewis
Sweepette	NFFS $3	??	HLG	Lee Hines
Sweepette 18	NFFS J82	18"		
Sweepette 19	NFFS $3	19"	HLG	Lee Hines
Tern II:	MA 5/93 #736	18"	OHLG	
Texas Bo-Weevil	NFFS $3	17"	HLG	Don Chancey
Thermal Piglet	Campbell kit	18"	Campbell's Kits	
Thermic 20	FF 12/98 p5	17"	HLG	Jetco kit
Thiszit	FF 01/01 p5	9"	Catap	Crosetto
Tiny Piglet	NFFS $3	??	HLG	Campbell
Upstart-4	MA 1/81	??	IHLG	Drela
US Kid	NFFS $3	??	HLG	Tom Peadon
WS-III	NFFS $3	??	HLG	Joe Wagner
Wasp VI	NFFS J85	??	OHLG	Mike Stoy MA 8/81 p57 #343
Z-21	FF 11/98 p13 $3	21"	HLG	Stan Buddenbohm
Zenith	MA 12/91p61#705	18"	OHLG	pop wing DT
Zweibox	NFFS $3	??	HLG	John Odenkamp
~	BH-121			

NFFS plans can be ordered from http://www.freeflight.org/ Most are $3.
* = NFFS Model of the Year winners

AMA plans can be ordered via http://www.modelaircraft.org/Plans/plansnew.htm
Most HLG plans are a single sheet priced at 3.75.

Books:

"Airfoils at Low Speeds" Selig, Donovan, Frasier SoarTech #8 1989
$20 SoarTech Publications, 1504 N. Horseshoe Cir., Virginia Beach
VA 23451 herkstok@aol.com Also see Dr. Selig's web site at
http://amber.aae.uiuc.edu/~m-selig/

"Flying Hand Launched Gliders" John Kaufmann, William Morrow 1974
Now available in reprint from NFFS Publications see below for
address or http://www.freeflight.org/ $10 members $12 non
[IMHO an EXCELLENT reference on building and trimming HLGs - rgk]

"Handbook of Model Rocketry", G. Harry Stine, Wiley 1994,

"Hey, kid, ya wanna build a model airplane?", Bill Warner, 1991
TAB books ISBN 0-8306-1040-5.

"Model Aircraft Aerodynamics." by Martin Simons, Argus Press
(U.K.), Third Edition 1994; (probably)

"Model Rocket Design and Construction", Tim Van Milligan, Kalmbach
1995 tvm@apogeerockets.com http://www.ApogeeRockets.com

"Throw it out of sight", Lawrence F. Abrams Dillon Press
Minneapolis MN 55415 ISBN 0-87518-247-X 629.133

[anyone know the title or source for this oldie???], Bill Winter,
1951

[Many tool and woodworking books can be found in any public
library #684.08-.09; aeronautics books are usually around #629.133]

Publications:

NARTREK, c/o Lew Proudfoot 310 Dover Court Allen, TX 75002
lewis_proudfoot@comsys.rockwell.com or Dr40Lew@aol.com

NARTS, P.O. Box 1482, Saugus, MA 01906 narts@nar.org
http://www.nar.org/NARTS

NFFS digest, 3317 Pine Timbers Dr. Johnson City, TN 37604 $20/year
txtimer@tricon.net or http://www.freeflight.org/

NFFS plans, 203 Chevro Lane, Bellevue, NE 68005
hsperzel@aol.com or http://www.freeflight.org/

NFFS publications, P O Box 7967, Baltimore MD 21221
rmclinden@earthlink.net or http://www.freeflight.org/

Zaic yearbooks, Model Aero Publications, P O Box 135, Northridge, CA
91343

URLs:

http://www.monmouth.com/~jsd/fly/how/htm/title.html	how planes fly
http://www.nesail.com/trimhlg.htm	trimming HLGs
http://naca.larc.nasa.gov/cit.html	NACA bibliography
http://amber.aae.uiuc.edu/~m-selig/ads/coord_database.html	Airfoil database
http://www.iit.edu/~kallend/rock.html	John Kallend's rocket page
http://aeromodel.com/scat	Southern California FF

Catalogs:

Aerospace Specialty Products arspecprod@aol.com
http://www.asp-rocketry.com

ARG, 130 Matheson Blvd East #10, Mississauga, Ontario, Canada L4Z1Y6
(905)501-0456 70711.133@compuserve.com

Apogee Components Inc., 1431 Territory Trail, Colorado Springs, CO
80919-3323 (719) 548-5075 tvm@apogeerockets.com

http://www.ApogeeRockets.com

Campbell's Custom Kits, P.O.Box 5996, Lake Worth FL 33461 305-968-1045
HLG Kits for Polly, Sweepette, Boll Weevil, and others
Or perhaps P.O.Box 3104, Muncie, Indiana 47307 -- (765)289-7753;
e-mail: souper30@gte.net.

Eclipse Components, 570 Buckeye Dr, Colorado Springs, CO 80919
(719) 598-6105 102100.1566@compuserve.com

Edmonds Aerospace, 13326 Preuit Place, Herndon, VA 22070,
(703)471-9313 RobEdmonds@aol.com
http://Members.aol.com/RobEdmonds/Edmonds.html

Holverson Designs, Inc., 25075 Co hwy L20, Soldier, Iowa 51572
holvrson@pionet.net http://www.pionet.net/~holvrson

Model Research Labs, 25108 Marguerite #160, Mission Viejo, CA 92692
regency@pacbell.net http://www.modelresearchlabs.com/

QCR, 7021 Forest View Drive, Springfield, VA 22150
http://www.cybertravelog.com/qcr

Rogue Aerospace Corporation aero@roguelight.com
http://www.roguelight.com

SIG, 401 S Front St, Montezuma, IA 50171 (800)247-5008
flysig@netins.net http://www.sigmfg.com/

Shecter Rockets, 20505 E Clear Spring Ct. Walnut CA 91789-3887 ($1)
fred.e.shecter@alum.mit.edu http://www.geocities.com/fredeshecter/PrdctInf.doc

Vaughn Brothers Rocketry JerryVBR@tcsn.net
http://www.vaughnbrothers.com

VectorAero KMcKiou@aol.com

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